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Technical Report

TEMPORARY POLAR STRUCTURES — MODIFIED T-5 BARRACKS

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TEMPORARY POLAR STRUCTURES — MODIFIED T-5 BARRACKS

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Type C Final Report

by

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ABSTRACT

The need for a comfortable building for quartering personnel in temporary polar camps led to the development of the Modified T-5 Barracks. This building of modular panel design is 28 feet wide, has a 9-foot ceiling, and is expandable in length on a 4-foot module. It was designed by ERDL and equipped with a steel-beam foundation by NCEL. The roof panels are supported on steel trusses made up of three sections bolted together.

A prototype 28- by 56-foot building was evaluated by NCEL. Heating studies were conducted in a controlled climatic laboratory. The prototype was then outfitted as a 10-bedroom quarters and shipped to Hallett Station, Antarctica, for in-service test. It was concluded from laboratory evaluation that the building is suitable for housing personnel in temporary polar camps.

CONTENTS

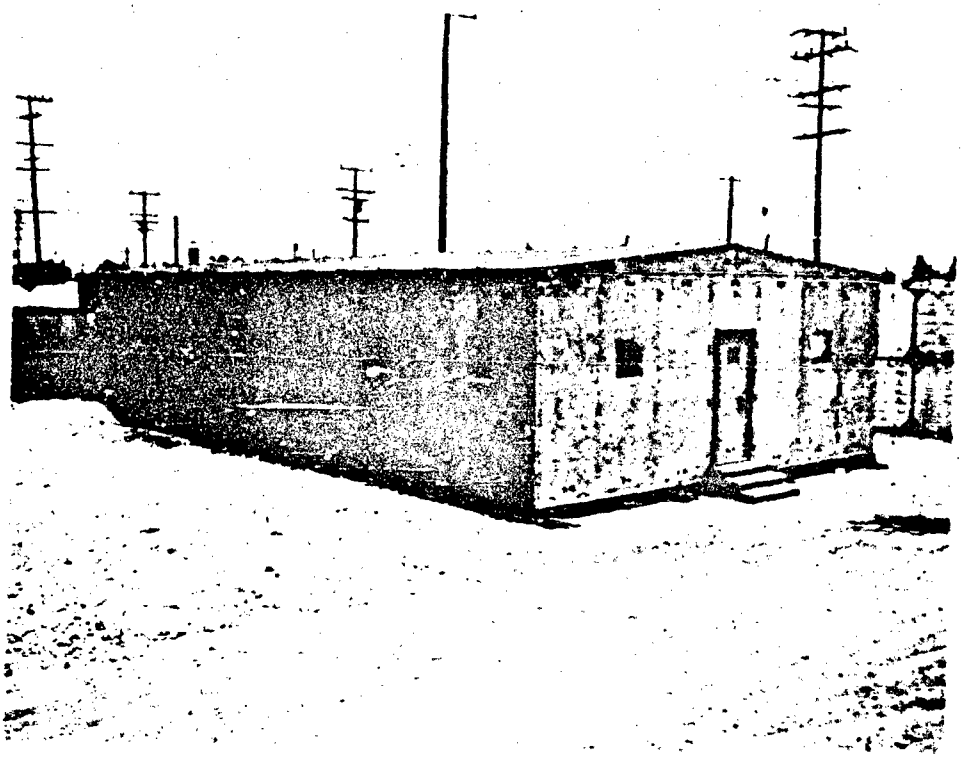

Figure 1. Modified T-5 Barracks exterior.

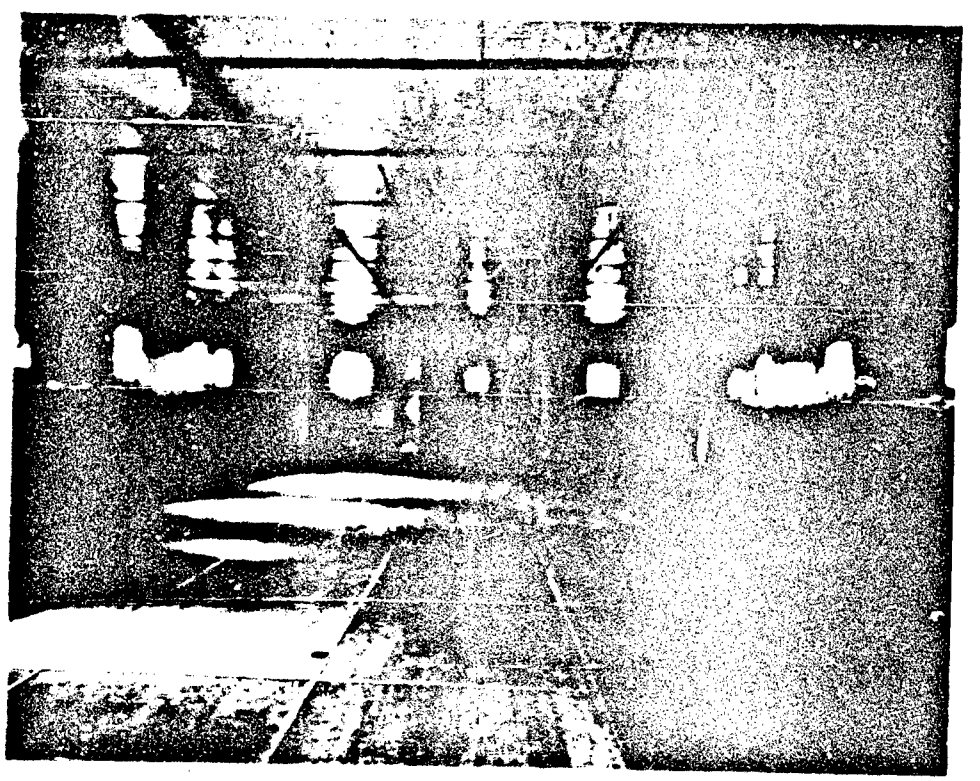

Figure 2. Modified T-5 Barracks interior.

INTRODUCTION

Comfortable quarters for personnel living in polar regions is essential to morale and consequent productiveness of a work force. This requirement is particularly critical in isolated regions where recreational facilities are limited and personnel are often confined to a building for long periods. Living conditions in past polar developments have been quite austere, but more recent developments have been aimed at providing greater comfort.

This report covers the development of a prefabricated panelized building suitable for quartering personnel in polar regions. It is also suitable for related uses, such as mess hall and galley, office, recreation, and medical facilities at temporary polar activities. It was designed after the Army T-5 Arctic Building and given the designation Modified T-5 Barracks (Figures 1 and 2).

BACKGROUND

Between 1959 and 1961 a 20-foot-wide Army T-5 building was evaluated at Squaw Valley, California, and Point Barrow, Alaska, to determine its suitability as a barracks building for temporary polar camps. A 52-foot-long building was used for this barracks. It was divided into five 8- by 12-foot bedrooms, an 8- by 16-foot lounge, and an 8- by 16-foot washroom and head. The remaining space was allocated to a 4-foot-wide hallway to service the bedrooms and an 8- by 12-foot heater room. The layout of the barracks is shown in Figure 3. The eave height in the T-5 building is 8 feet, and the headroom under the roof trusses, which are spaced 4 feet on centers, is 7 feet. Some of the bedrooms were fitted with double bunks and others with single bunks.

The weight of the 20- by 52-foot building packaged for shipment was 19, 155 pounds, and it occupied 1434 cubic feet. This weight and cube was for the building only; it did not include the outfitting.

Upon completion of the evaluation, which included occupancy by both military and civilian personnel in temperatures from 50 F to -50 F, and with rain, snow, and high winds, it was found that:[1]

1. Repeated erection and disassembly did not damage the building panels.

2. The structure was weathertight except for minor leakage at the truss seats in the top of the wall panels.

3. The closure devices on the outside doors were difficult to operate, and positive closure required special care.

4. Noise originating in any area within the building was easily heard throughout the building.

5. All long-term occupants expressed a desire for one-man bedrooms.

6. Clearance over the top bunk was critical in the bedrooms containing double bunks.

7. The 7-foot clearance under the trusses gave many occupants a feeling of discomfort.

8. The bedrooms were too cramped for long-term two-man-occupancy comfort.

From this evaluation, it was concluded that the Army T-5 building was generally satisfactory for temporary polar camps with an anticipated life of 1 to 5 years, but that:

1. A building of greater width and height was needed to improve occupancy comfort.

2. The roof truss connectors in the wall panels should be improved to prevent leakage.

3. The closure devices on the outside doors should be simplified.

4. An acoustical ceiling should be provided to reduce noise transmission within the building.

5. Larger bedrooms should be provided for long-term occupants.

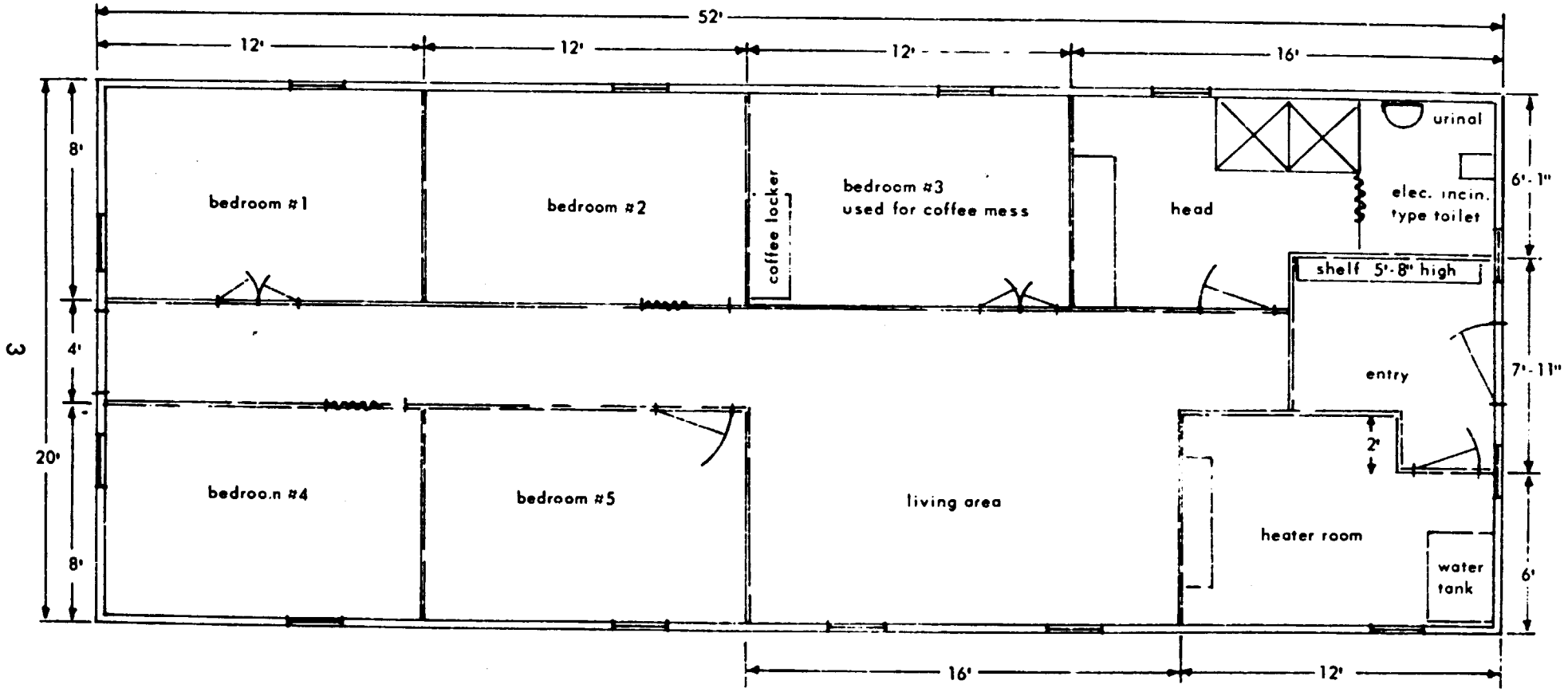

Figure 3. Floor plan of 20- by 52-foot T-5 quarters building.

These findings and conclusions resulted in the development of the Modified T-5 Barracks. The barracks was designed by the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, under the sponsorship of the Bureau of Yards and Docks. A prototype of this design was fabricated by the Coast Guard Yard, Curtis Bay, Maryland, and delivered to the U. S. Naval Civil Engineering Laboratory in 1962 for evaluation and development of outfitting for use as a quarters building. The building was evaluated by the Laboratory in 1962 and 1963.[1,2]

Heating tests on the prototype were conducted in a controlled climatic laboratory at Point Mugu, California.[2] These tests included heat-loss studies on the structure and the evaluation of two types of heating systems in temperatures to -50 F. Previous to these tests and in conjunction with moving the building to the cold chamber, erection and disassembly studies were conducted.[1] In November 1963 the prototype building was outfitted as a 10-bedroom quarters and shipped to Hallett Station, Antarctica, for in-service test.[3]

CONCEPT

The general construction of the Army T-5 Arctic Building was found to be quite satisfactory, so the concept for the Modified T-5 Barracks was based on using the T-5 type of construction, but overcoming the width and ceiling-height limitations. A width of 28 feet was selected to provide a 4-foot passageway through the length of the building at the center, and still have a space 12 feet wide on each side of the passageway. A ceiling height of 9 feet was selected to provide adequate headroom for double bunks and allow greater circulation of air to reduce stratification.

An open-web-type foundation was required to support the building on snow, ice, and permafrost and provide air circulation under the building to prevent or retard melting of the underlying media.

CRITERIA

General criteria applicable to all structures for temporary polar camps and stations were used in the development of the Modified T-5 Barracks:

1. A 5-year useful life without extensive repair.

2. Structural adequacy for winds up to 100 miles per hour.

3. Satisfactory operation in temperature to -65 F.

4. Easy erection under adverse conditions.

5. Suitability for use on frozen ground, sea ice, and deep snow.

6. Air-transportability by C-130 aircraft.

7. Maximum use of Federal standard stock items and readily available commercial items.

Specific criteria for development of the Modified T-5 Barracks were:

1. Structural adequacy for snow loads up to 54 psf.

2. Adequate floor strength to support 50 psf.

3. A width to permit a 4-foot passageway through the center with 12-foot-wide rooms on each side.

4. An acoustical ceiling to reduce noise transmission within the building.

5. A prefabricated foundation suitable for use on snow, sea ice, and permafrost.

DESCRIPTION

The original design of the Modified T-5 included a floor plenum heating system. This system, which is described in Appendix A, was evaluated in the heating studies on the prototype.[2] As this heating system was not recommended for adoption, it has not been included as a basic part of the structure.

The floor for the prototype was modified and a steel-beam foundation suitable for use on snow, ice, and permafrost was designed by the Laboratory. Modifications to the floor were necessary in order to develop the most economical foundation for the building.

A schedule of the drawings for the building, the modified floor, and the steel-beam foundation are given in Appendix B. Copies of these drawings are available from the sources indicated.

Building

The Modified T-5 Barracks is a prefabricated, straight-sided, frameless wooden building with load-bearing walls and a 1:10 gable roof supported on trusses. It is 28 feet wide and 10 feet high at the eaves. The basic building is 56 feet long, but the building can be made any desired length on a 4-foot module. The quantity and weight of the parts for the basic building are given in Table 1. The net weight of the building is 22,738 pounds; the packaged weight is 31,718 pounds; the packaged cube is 2252 cubic feet.

The building panels are wood-framed, stressed-skin, plywood units assembled with cold-setting glue and staples. They are insulated with blanket-type fiberglas and moisture-sealed with an aluminum-foil vapor barrier on the warm side of the insulation. The panels are connected with tongue-and-groove joints and surface-mounted wedge clips (Figure 4). Except for the corners and the end gables, all panels are 4 feet wide.

The roof is supported by open-web steel trusses made up in three sections which bolt together (Figure 5). They are spaced 4 feet on centers and secured to the wall panels with button connections. Steel truss pockets are provided in the top of the wall panels and secured with hardwood wedge connectors. Wooden battens and a metal ridge cap are used to seal the roof.

Panels containing a window are interchangeable with all other 4-foot-wide wall panels. The windows are triple-glazed. Door panels are normally located at the center of each endwall; however, they are also interchangeable with all wall panels.

The ceiling is supported on T-bar hangers which rest on the bottom chords of the trusses 9 feet above the floor. One-inch-thick fiberglas board panels cut to size are used for the ceiling. This ceiling, described in Appendix C, should improve acoustics in the building as well as provide insulation.

Modified Floor

The original floor design for the building did not have the right reinforcement for the most economical foundation; therefore, a modified floor was designed to replace the original design. Development of the modified floor is discussed in Appendix D. The construction of the floor panels is the same as the wall- and roof-panel construction, except that the thickness is 3-1/8 inches instead of 3 inches. The additional thickness is due to the use of 3/8-inch plywood on the upper side of the floor panels instead of the 1/4-inch plywood skin used on other panels.

Table I. Quantity and Weight of Panels and Trusses Required for a 28- by 56-foot Modified T-5 Barracks

Units	Quantity	Unit Weight (lb)	Total Weight (lb)
Floor Panels			
Outside	28	164	4,592
Inside	14	126	1,764
		Total Floor Weight	6,356
Wall Panels			
Window	18	168	3,024
Solid	16	162	2,592
Corner side	4	84	336
Corner end	4	152	608
Door	2	312	624
Gable	4	52	208
		Total Wall Weight	7,392
Roof Panels			
Inside	24	210	5,040
Corner	4	214	856
		Total Roof Weight	5,896
Truss	13	238	3,094
		Total Weight of Building	22,738

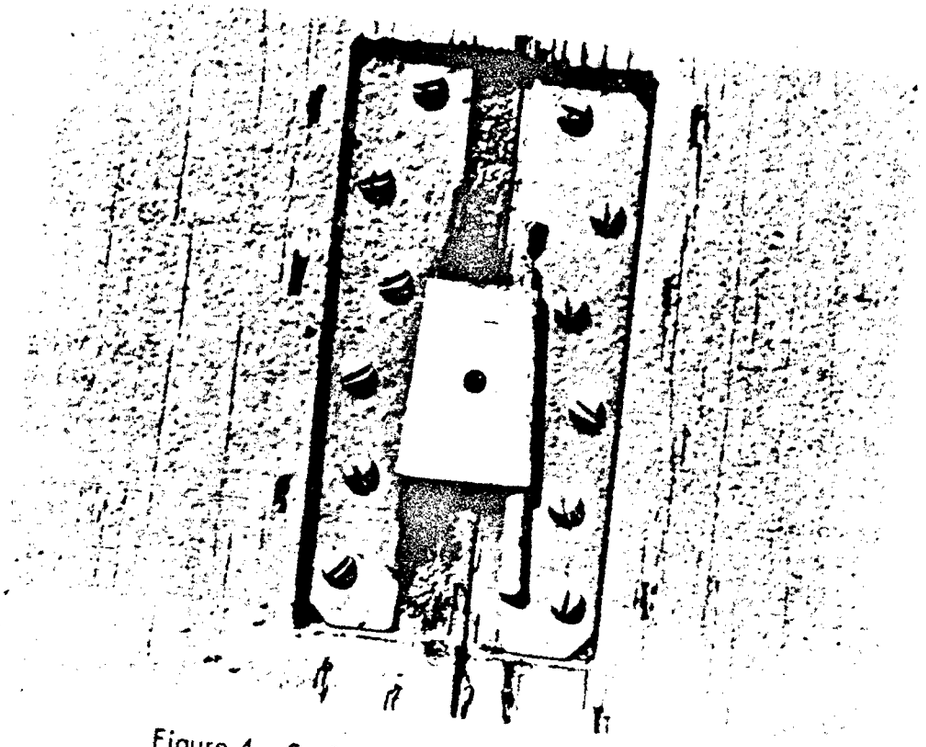

Figure 4. Surface-mounted wedge clip.

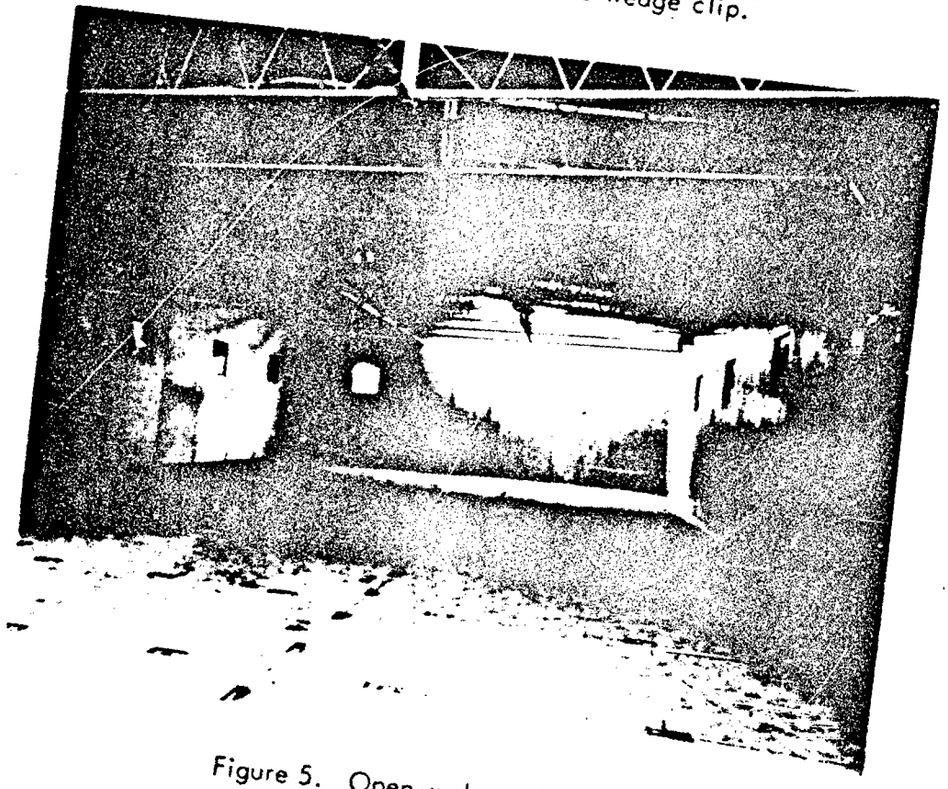

Figure 5. Open-web steel trusses.

Two 10-foot panels and an 8-foot panel are placed end to end across the 28-foot width of the building. Stiffeners are placed parallel to the length of the panels, so that the panels require end support rather than edge support.

The tongue-and-groove connection between floor and wall panels is made with the tongue in the top surface of the floor panel and the groove in the bottom edge of the wall panel. If the tongue and groove are reversed, moisture can seep into the building.

Steel-Beam Foundation

The steel-beam foundation, based on the T-5M foundation discussed in Reference 4, can be used on snow, ice, permafrost, sand, and gravel. It consists of four longitudinal load-bearing members connected by cross bracing on 8-foot centers. The longitudinal members, 15-inch-deep open-web steel beams, are located under each edge of the building and 10 feet from each edge where the 8- and 10-foot floor panels are joined together. The beams are made up of 16-foot sections connected end to end with bolts. The cross bridging consists of steel rods threaded on ends. The ends of the rods fit into slots in the web of the beams and are held in place with nuts.

The foundation is designed for continuous bearing or point support of the longitudinal members. For point support, all members are supported at 16-foot intervals. Continuous spread footings are required under all four longitudinal members on snow.

In order to use this foundation, the modified floor described above must be used in place of the original floor design.

PERFORMANCE

The basic 28- by 56-foot Modified T-5 Barracks has a size, weight, cube, and erection time 60 percent greater than the experimental 20- by 52-foot T-5 barracks. However, the occupancy density is 80 percent greater. In addition to providing space for more occupants, the wider building permits better interior arrangement.

Erection

The Modified T-5 was erected and disassembled three times by a six-man crew. The erection time of 114 manhours for the first erection was cut down to 59 manhours by the third erection. Both were made at temperatures near 70 F. These erection times did not include the foundation. A crane was used for placing the trusses and roof panels.

Heating Studies

The Modified T-5 was tested in a controlled climatic laboratory to determine the heat loss and compare the effectiveness of the floor plenum heating system originally designed for the building with an overhead duct heating and air-conditioning system.[2] The two systems are described in Appendix A. In addition to these studies, a 1-inch-thick fiberglas board ceiling was installed and its effectiveness in reducing heat loss was tested.

The heat loss studies showed that:

1. The overall heat loss is 0.158 Btuh/sq ft/°F at a wind velocity of 2 to 3 miles per hour.

2. The natural air infiltration rate is approximately 0.6 air changes per hour, or 11.1 cubic feet per hour per foot of joint based on half the total crack length.

3. The 1-inch-thick fiberglas board ceiling reduced the heat loss 26 percent and was 11 percent more effective than a ceiling of 1/8-inch perforated hardboard.

A comparison of the two heating systems showed that the floor plenum system gave minimal stratification; however, it did not make any provision for humidification or fresh-air ventilation, and it did not heat corner rooms with two outside walls, which could be accomplished with the overhead duct system. The shipping weight and cube of the floor plenum system were both nearly four times greater than the overhead duct system, and the two plenum furnaces required more than twice the floor space required by the forced-air furnace.

It was concluded from these studies that the overhead duct system more nearly meets the requirements for comfort-conditioning polar structures than the floor plenum system.

APPLICATION

The Modified T-5 Barracks was used as the basic building in the development of a temporary polar camp which would provide all required facilities for 50 men and be expandable in 50-man increments to 200-man capacity.[5,6] This camp was designed for a minimum life of 5 years, and is suitable for use in any polar region.

The concept for the basic building is a duplex comprised of two facilities joined by a service core. It is 128 feet long, consisting of two 52-foot-long facilities and one 24-foot service core. The service core contains the heating system, head, washroom, and laundry.

The duplexes in the temporary polar camp were outfitted for use as quarters, galley, mess hall, recreation, administration, communications, medical, and utilities. A typical floor plan, showing the service core and two quarters units, is shown in Figure 6.

A prototype of the Modified T-5 was outfitted by the Laboratory as a 10-bedroom quarters building in 1963.[3] The outfitting was based on the temporary polar camp design. Modular partitions (Figure 7) were used to provide the floor plan shown in Figure 8. Each room was furnished with a standard Navy bunk, an 18- by 30-inch wardrobe, a writing table, and two folding chairs. The lounge was furnished with chairs and tables.

The building with outfitting was shipped to Hallett Station, Antarctica, during Deep Freeze 64 for in-service test.[3]

FINDINGS

1. The net weight of the Modified T-5 Barracks without foundation is 22,738 pounds. The weight packaged for shipment is 31,718 pounds, and the packaged cube is 2252 cubic feet.

2. The building can be erected on a prepared foundation by a six-man trained crew in 59 manhours when the outside temperature is about 70 F.

3. The overall heat loss of the building is 0.158 Btuh/sq ft/°F at a wind velocity of 2 to 3 miles per hour. The natural air-infiltration rate is approximately 0.6 air changes per hour.

4. The fiberglas board ceiling reduces the heat loss 26 percent.

CONCLUSIONS

1. The Modified T-5 Barracks appears well suited for housing personnel in temporary polar camps.

2. The Modified T-5 Barracks should be used in temporary polar camps for applications which require a 28-foot-wide building.

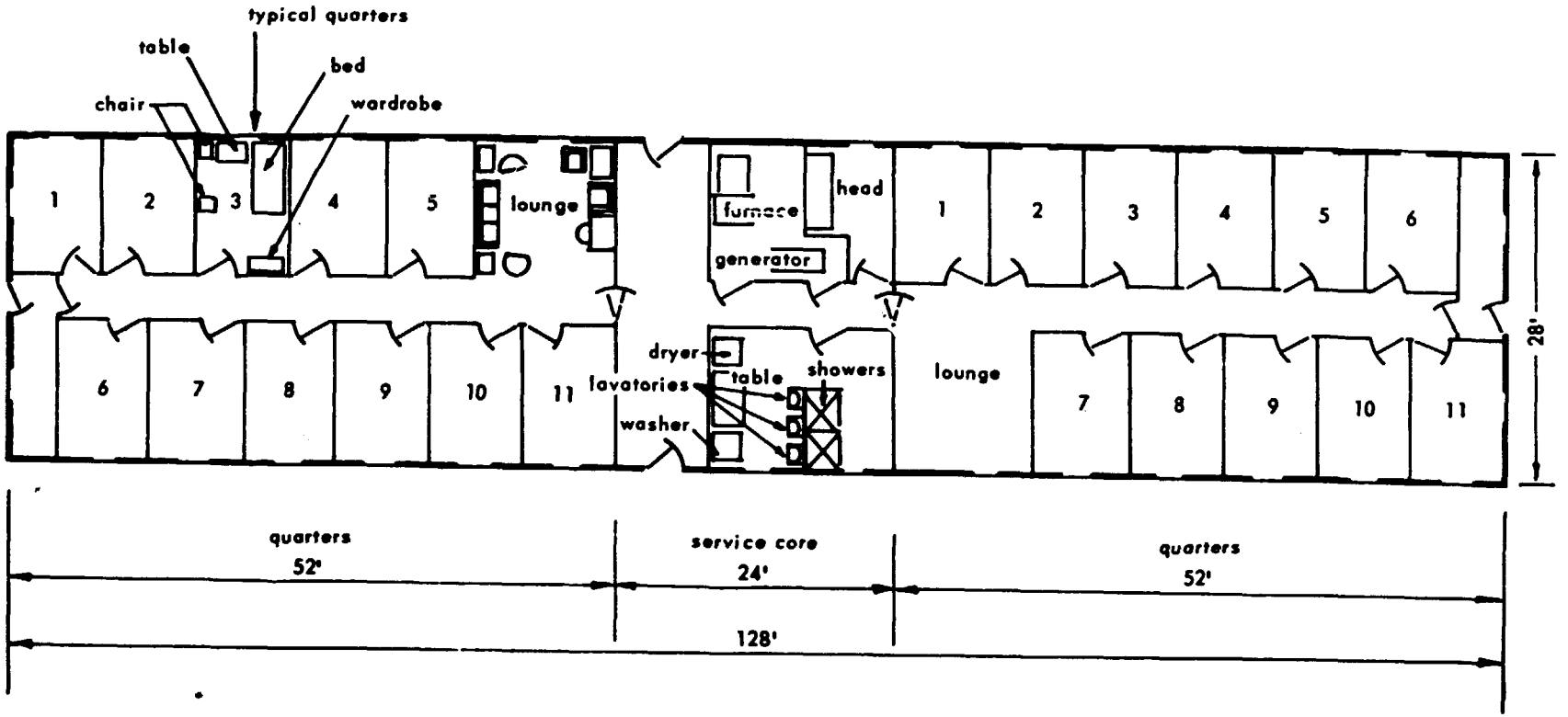

Figure 6. Floor plan of duplex arrangement providing two quarters units and a service core for a temporary polar camp.

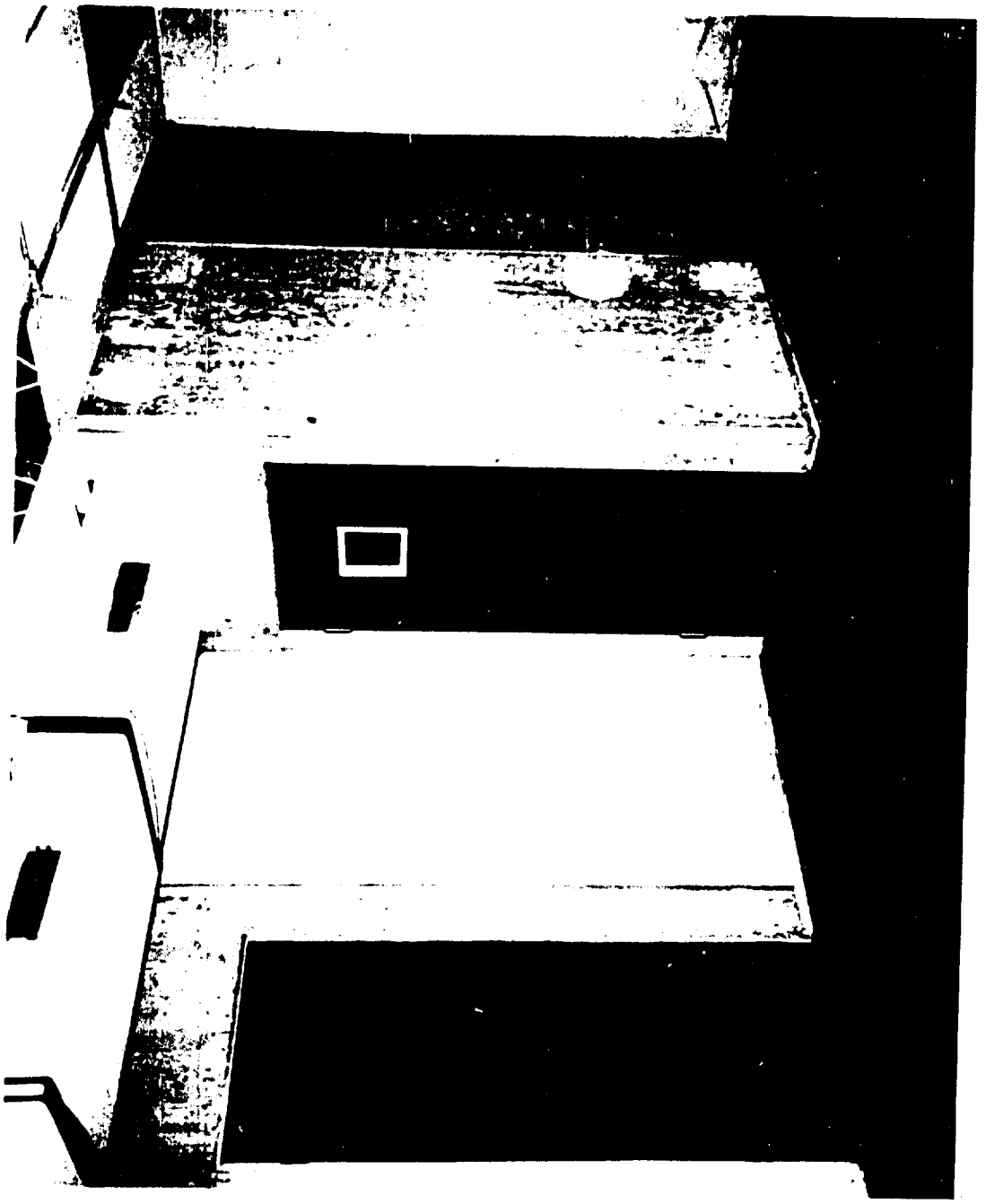

Figure 7. Modular partitions for the prototype 10-bedroom quarters building.

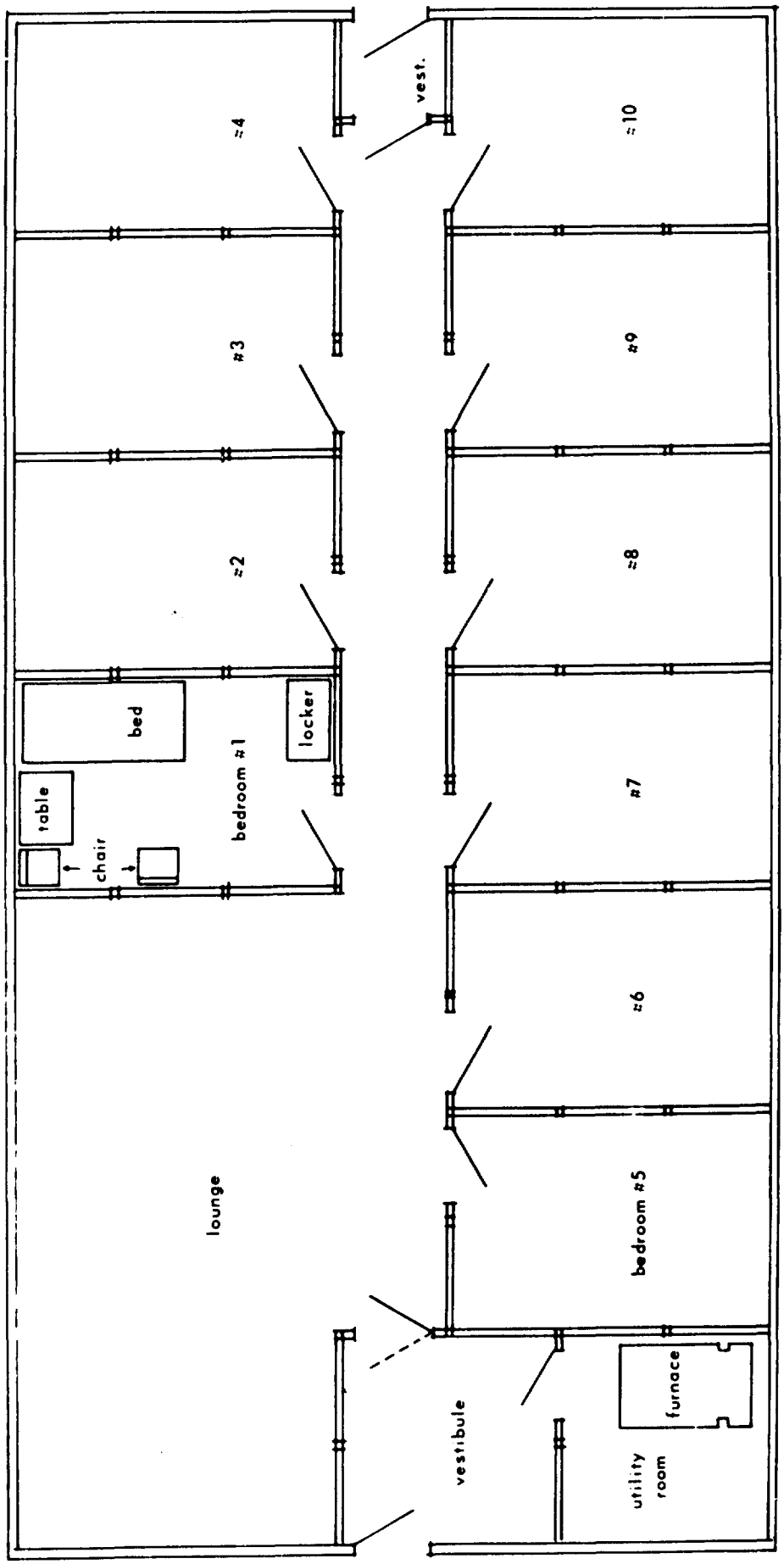

Figure 8. Floor plan of the prototype 10-bedroom quarters building.

ACKNOWLEDGMENTS

Mr. J. P. Cosenza compiled much of the data for this report; Mr. C. R. Hoffman conducted the heating studies.

REFERENCES

1. NCEL Technical Note N-484, Temporary Polar Structures — Preliminary Evaluation of the Modified T-5 Barracks, by J. P. Cosenza, December 1962.

2. NCEL Technical Report R-286, Modified T-5 Barracks — Controlled Climatic Heating Studies, by C. R. Hoffman, 12 May 1964.

3. NCEL Technical Note N-550, Modified T-5 Barracks — Erection and Outfitting as a Quarters Building, by J. P. Cosenza, C. R. Hoffman, and R. W. Hansen, 20 December 1963.

4. NCEL Technical Report R-265, Temporary Polar Structures — Maintenance Shelter, by J. B. Camm, 26 November 1963.

5. NCEL Technical Report R-288, A Temporary Polar Camp, by G. E. Sherwood, 26 March 1964.

6. NCEL Technical Note N-540, Specifications for a Temporary Polar Camp, compiled by G. E. Sherwood, 23 October 1963.

Appendix A

HEATING SYSTEMS

FLOOR PLENUM SYSTEM

The original Modified T-5 Barracks heating system design consisted of two 95,000-Btuh oil-fired forced-air furnaces, a panelized plenum system which covered the entire floor of the building, and a fuel-supply system. Packaged for shipment, the system weighed 8303 pounds and occupied 1049 cubic feet.

The furnaces were located on each side of the door at one end of the building. They were mounted horizontally and were connected to the floor plenum with sheet-metal transition sections. A 160-gallon fuel tank was located inside the building adjacent to each heater. Both heaters had automatic controls and could be operated independently.

The floor plenum was made up of 49 panels 4 feet wide, 8 feet long, and 5-1/2 inches deep. The tops of the panels were covered with plywood to provide a wearing surface for the floor. The total weight of the plenum was approximately 3300 pounds.

In operation, the warm air was pushed into one end of the plenum and exhausted through ducts in the opposite end. The ducts contained blowers to assist circulation of the air through the plenum.

OVERHEAD DUCT SYSTEM

An overhead duct heating and air-conditioning system was tested to compare its effectiveness with that of the floor plenum heating system. The system consisted of a 140,000-Btuh oil-fired forced-air furnace, sheet-metal ductwork, fiberglas board ducts, dampered registers, and a humidifier. Packaged for shipment, the system weighed 1250 pounds and occupied 219 cubic feet.

The furnace was located in one corner of the building. It was equipped with a 2000-cfm forced-circulation blower located below the heat exchanger. Warm air discharged at the top of the furnace was carried to the centerline of the building through rectangular sheet-metal ductwork, then down the centerline below the trusses through 10- by 30-inch fiberglas board ducts. Four- by fourteen-inch dampered registers cut into both sides of the supply duct every 8 feet discharged

the air across and down toward the outside walls. The air was returned to the furnace through two 12-inch-diameter duct inlets in the ceiling a few feet from the furnace. Some 500 cfm of ventilation air (2.1 air changes per hour in the habited space) was drawn into the building through an opening in the sidewall and mixed with the return air before it entered the furnace.

A humidifier was mounted in the straight section of hot-air duct between the furnace and the transition to the fiberglas duct. This unit had a capacity of 12 pounds of water per hour, which was atomized mechanically by dripping on a rapidly spinning disc.

The controls on the furnace were standard for an oil-fired furnace, with two exceptions. A remote-bulb thermostat was used in the return-air duct in place of a wall thermostat, and an identical thermostat was used in the warm-air delivery duct to maintain a low-temperature limit on the supply air. This low-limit thermostat was required to maintain discharge-air temperatures at a comfortable level because of the addition of outside ventilation air.

Appendix B

SCHEDULE OF DRAWINGS FOR THE MODIFIED T-5 BARRACKS

Building

U. S. Army, Engineer Research and Development Laboratories, Fort Belvoir, Virginia, Drawing Set D-13200: (Sheets No. 18 through 20 are replaced by the NCEL drawings listed under Modified Floor below. Sheets No. 25 through 38 were for the floor plenum heating system, which was eliminated. The perforated hardboard ceiling detailed on Sheet No. 39 is replaced with the fiberglas board panels described in Appendix C.)

Sheet No.	Title
1	Schedules
2	Exterior Views
3	Assembly Diagram
4	Floor Plan
5	Longitudinal Section
6	Transverse Section
7	Assembly Details
8	Wall Panels
9	Wall Panels
10	Door Panel
11	Door
12	Wall Panels
13	Wall Panels
14	Gable Panels
15	Roof Panels
16	Roof Panels
17	Roof Panels

Sheet No.	Title
21	Screen Door
22	Truss
23	Center Roof Truss
24	Ceiling Support Details
39	Key Plan and Liner Details

Modified Floor

Sheets No. 18 through 20 in the above drawing set are replaced by NCEL Drawings:

Y&D Drawing No.	Title
943666	Floor Plan
943667	Panel Details
943668	Panel Details
943669	Panel Details
943670	Corner Details

Foundation

Y&D Drawing No.	Title
943712	Temporary Polar Camp — Foundation System Fabrication

Appendix C

FIBERGLAS BOARD CEILING

The 1/8-inch perforated hardboard in the original design of the Modified T-5 Barracks is replaced by fiberglas board panels. The fiberglas is supported on the same aluminum T-sections used to support the hardboard. The ceiling is 1-inch semiridged acoustical fiberglas board faced with a washable decoratively embossed vinyl-plastic film. It can be purchased in 2- by 4-foot panels and trimmed to exact size.

The fiberglas board costs $251 as compared to $135 for perforated hardboard, and requires 130 cubic feet of shipping space as compared to 17 cubic feet for perforated hardboard; however, its weight of 266 pounds is considerably less than the hardboard, which weighs 686 pounds. Since weight is more critical than cube, the cost is the main disadvantage. The additional initial cost is justified by the large savings in heat.

Appendix D

MODIFIED FLOOR

To provide the most economic foundation for the Modified T-5 Barracks, the floor-panel design was changed by placing stiffeners in the panels longitudinally, so that only end support is necessary for the panels. This reduces the foundation beam length requirement by approximately one-half. Four longitudinal beams are used to support the ends of the panels, and cross bridging of steel rods is used between beams.

The T-5M foundation, on which this design is based, consists of four longitudinal beams with 6-inch-deep transverse members spanning between beams at 4-foot intervals. This produced a grid system which supported each floor panel completely around its perimeter. The T-5M Maintenance Shelter foundation could be used with the Modified T-5 Barracks, but would be overdesigned as the modified floor panels are adequate to support 50 psf with only end support.

The open-web beams required for a 28- by 56-foot building weigh 3696 pounds. The 6-inch-deep transverse members used in the T-5M foundation weigh 5040 pounds. This results in a total net weight of 8736 pounds. The cross bridging used in the Modified T-5 Barracks to replace the transverse members weighs only 500 pounds, resulting in a net weight of 4196 pounds, or approximately one-half the weight of the T-5M foundation. The estimated cost of this foundation is $2000 as compared with $3400 for the T-5M foundation. Redesign of the floor is justified by the reduction in weight and cost of the foundation.